THE CRUSHED STONE JOURNAL

Official Publication
The National Crushed Stone Association

In This Issue—

Methods of Inspection of Mineral Aggregates

Low Cost Paved Farm-to-Market Roads

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DECEMBER, 1929

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IMPORTANT ANNOUNCEMENT

There was held at the Thirty-Second Annual Meeting of the American Society for Testing Materials, Atlantic City, June 24 to 28, 1929, a Symposium on Mineral Aggregates, announcement of which was made in the November issue of the "Journal." Since that time a more careful reading of this publication would seem to warrant that specific attention again be directed to it, as it contains a vast amount of information which should be of decided interest and value to crushed stone producers. For your information there is given below a list of the papers included in the Symposium:

CONTENTS

Introduction—R. W. Crum.
Methods of Inspection of Mineral Aggregates—A. S. Rea.
Fine Aggregate in Concrete—H. F. Gonnerman.
Fine Aggregate in Mortar and Plaster—J. C. Pearson.
Fine Aggregate in Bituminous Mixtures—H. W. Skidmore.
Effect of Aggregates Upon Stability of Bituminous Mixtures—Prevost Hubbard.
Influence of Quality of Coarse Aggregate on Strength of Concrete—F. C. Lang.
Influence of Coarse Aggregate on the Durability of Concrete—F. R. McMillan and George W. Ward.
Influence of Mineral Composition of Aggregates on Fire Resistance of Concrete—S. H. Ingberg.
Aggregates for Low-Cost Untreated Roads—C. N. Conner.
Mineral Aggregates for Sewage Disposal and for Railroad Ballast—H. F. Kriege.
Needed Research on Mineral Aggregates—F. H. Jackson.
General Discussion.

Copies of this publication may be obtained from the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., at the following prices: 1 to 9 copies, $1.00; 10 to 49 copies, $.75; over 50 copies, $.60.

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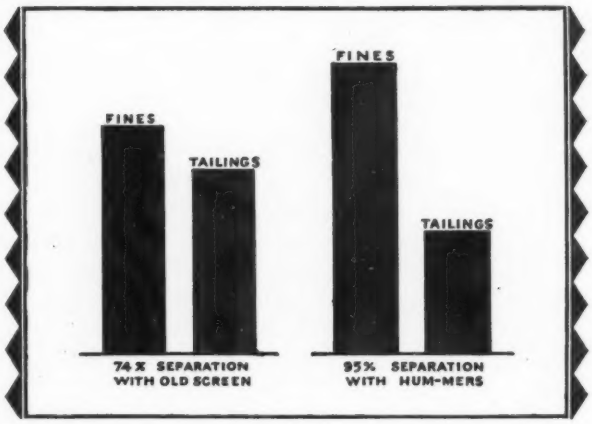

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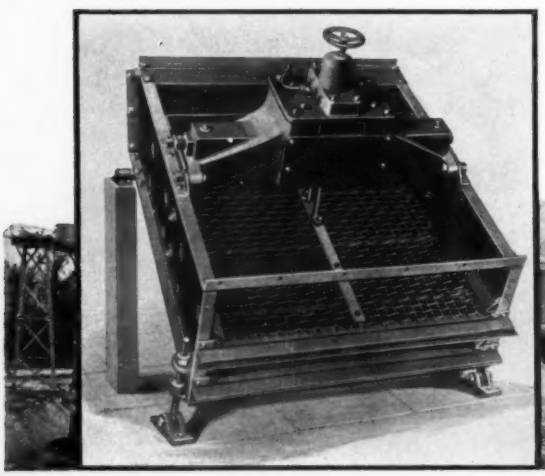

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Methods of Inspection of Mineral Aggregates

BY A. S. REA

Chief Engineer, Bureau of Tests, Ohio Department of Highways, Columbus, Ohio

From Symposium on Mineral Aggregates, held at the Thirty-Second Annual Meeting of the American Society for Testing Materials, Atlantic City, N. J., June 24 to 28, 1929.

SYNOPSIS

This paper discusses the methods of inspection of mineral aggregates from a technical standpoint. The discussion considers: (1) Preliminary investigations, including material surveys and reconnoissance surveys; (2) inspection during construction, including inspection at source of supply and at destination; (3) methods of sampling; and (4) field tests.

The important things to be observed in inspection at the source of supply and at destination are pointed out and the advantages of each method of inspection are discussed. The importance of proper sampling is emphasized and the standard methods of the Society are recommended as a guide in formulating instructions to inspectors. The screen test, silt test, colorimetric test for sand and test for weight per cubic foot are named as the more important field tests.

Mineral aggregates play a most important part in the construction work throughout the country. Our highways and streets, for example, are over 90 per cent mineral aggregates and concrete construction of all kinds will average 85 per cent aggregates. Therefore adequate inspection and tests are necessary to the protection of the enormous annual investment in these materials.

ASSUMING that provision has been made in the matter of organization by the user, whether it be a unit of national, state, county, or municipal government, or private organization to handle inspection of materials, certain fundamental rules can be laid down in the methods to be followed. With the varying conditions existing both as to locality and types of construction it is recognized that it is impracticable to formulate specific directions which would be applicable generally. For this reason no attempt will be made to enumerate in detail, instructions to be followed in the inspection and sampling of materials. The subject will be discussed for the most part by outlining in more or less general terms the methods and policies which have been used successfully by engineering organizations, and references will be made to standard methods or procedures that have been adopted.

The subject will be considered under the following sub-titles:

1. Preliminary Investigations;
2. Inspection During Construction;
3. Methods of Sampling; and
4. Field Tests.

Preliminary Investigations

Preliminary investigations of aggregates may be said to cover any examination or inspection of the source of supply prior to construction. In practice this may consist of either geological or material surveys, or reconnoissance or special preliminary examinations.

Material Surveys:

A number of the states as well as other political sub-divisions of government have had very complete surveys made of their local resources. This has been especially true with reference to deposits of mineral aggregates. In some cases the survey has been conducted under the supervision of the state geologist, while in others it has been under the direction of the highway department. The information collected in a survey of this sort may be of inestimable value in planning and carrying out a construction program. A materials survey involving the sampling and testing of the materials, is considered of such value that it is essential that the investiga-

tion should be in charge of someone who not only knows the geology of the state, but is also familiar with the character and use of construction materials.

Some of the important things to observe in a survey of this kind include the following: a detailed description of the deposit or quarry including the exact location; name of owner; the geological formation where applicable; the amount and character of overburden or stripping; approximate quantity available; whether material from the same source has been previously used, where and for what purpose, and with what results. Notation should also be made of the shipping facilities, the plant equipment, if it is a commercial plant, and the approximate capacity of the plant. A detailed record of the extent and location of the material represented by each sample should be made. For this purpose a sketch, both in plan and elevation, showing the thickness and location of the different layers is recommended.

Special Preliminary Surveys:

In those states where no general materials survey has been made and even in those where such a survey has been conducted at a much earlier date, where possibly conditions have materially changed since the original survey, it is often desirable to make a reconnoissance or special materials survey. The plan usually followed when a construction project is proposed is to have an examination or survey made to determine what local materials are available and also their suitability for the particular type of construction contemplated. In some states, where conditions are such that it is considered impracticable to ship in material for particular projects, the specific requirements for the mineral aggregates are based on the test results of the best material available locally. A careful study should be made by the engineer of all surface indications and exposures and a sketch or map should be made of the project and adjacent area, from which it may be determined whether it is more economical to haul from the local deposit than to ship material from a commercial plant by rail. The procedure to be followed and the data which should be collected are essentially the same as that noted under "Material Surveys," except that perhaps less detailed information will usually be required.

Inspection During Construction

Assuming that the contract has been awarded and that the contractor has advised the materials engineer as to the source from which he proposes to obtain his mineral aggregates, the method of handling the routine inspection may be either by inspection at the source of supply or by inspection at destination.

An inquiry as to the methods followed by various states, counties, cities and organizations in this respect will reveal a marked difference in policy in the matter of inspection. Some states, for example, strongly favor the inspection of all aggregates at their source. In others the tendency is for inspection at destination, while in most states a combination of the two methods in varying ratios is the policy. Conditions, of course, determine more or less the practicability of the best method to follow. The chief advantage in the inspection at the source of supply of any material is in avoiding delay awaiting the results of laboratory tests. It also practically eliminates the possibility of rejection on the job with the resulting expense and delays involving re-shipments, demurrage, etc. The chief objection to this method of those favoring inspection at destination is based on the high inspection charges where the shipments are light, together with the fact that where conditions are favorable the plant inspection as applied to aggregates is considered unnecessary. It is held that where the quality of the aggregate is not in question and the plant operation is efficient, so that the grading or sizing is properly controlled, it is a needless expense to provide for plant inspection under such conditions. Where the quality and the grading as evidenced by the character of the product received is not satisfactory, plant inspection may be desirable and economical. In this connection it might be said that the more general adoption of field tests, as applied to aggregates, has resulted in the elimination of many delays in awaiting the results of tests on samples sent to a central laboratory.

Inspection at Source of Supply:

It is not the intention to enumerate the duties of a plant inspector nor to go into detail regarding the inspection methods to be followed for each type or class of fine and coarse aggregate, but rather to outline the general practice normally followed at plants producing aggregates for construction work and to call attention to some of the precautions to be observed.

The materials inspector is stationed at the plant for one purpose—to see that material being shipped complies with the requirements of the specifications and is satisfactory in every way. It is his duty to see that

material being loaded is of approved quality and of satisfactory grading and uniformity, and in some cases to keep a record of the car weights. Inspectors located at plants furnishing fine and coarse aggregates should make a careful study of plant conditions and operations, with a view to being able to make suggestions on improving the quality or uniformity of the product. In taking samples of aggregate, whether they are for his own field tests or are to be sent to the testing laboratory, he should keep in mind at all times that the one fundamental requisite is that the sample must be representative of the material being sampled. It is often a very difficult matter for the inspector or engineer on the job to secure a strictly representative sample from a car or stockpile, particularly of coarse aggregate. The inspector at the plant has a much better opportunity to obtain proper samples while the material is being loaded into cars or bins.

One of the very important things for an inspector to observe at a plant producing gravel, crushed stone or slag is the size and uniformity of grading. Some of the factors affecting the size of coarse aggregate at the plant are: size and shape of screen openings; length of screen sections; the angle of screen with horizontal; the speed of screen rotation; and the rate at which the screen is fed. A general inspection and record of these conditions should be made by the inspector.

Inspectors at plants producing aggregates should see that coal, cinders, and other foreign materials are removed from cars or barges before the aggregate is loaded for shipment. When the calking of car bottoms is necessary, the inspector should see that it is done in such a manner and with such material that the aggregates will not become contaminated with foreign material during the unloading operation. The use of boards, roofing paper or burlap has been found to be the most satisfactory for this purpose and their use should be encouraged by the inspector.

One of the important duties of the plant inspector is to see that accurate records are kept of all shipments and test results. He should also see that all samples sent to the laboratory are properly marked and identified.

Inspection at Destination:

Considering the construction and building program as a whole it is probably a conservative guess that over 90 per cent of the inspection on aggregates is at destination. While a few engineering organizations provide for plant inspection for practically all of their construction work, most of the states, counties, cities and private organizations provide only for the inspection and testing of the aggregates after delivery. The ratio of plant inspection to inspection at destination as applied to other construction materials, particularly manufactured materials such as Portland cement and steel, would be much higher than with aggregates. This is due to the fact that the inspection of such materials as sand, gravel, stone and slag lends itself better to visual inspection and also perhaps to the fact that field tests are more adaptable to aggregates than to other classes of materials.

It has been found desirable by some organizations to handle the inspection of all materials at destination by specially trained materials inspectors. In most instances, however, the inspection of materials is supposed to be taken care of by the same engineer or inspector in charge of the construction work. Unfortunately the inspection of the materials has been in many cases sadly neglected. Too much dependence has been put upon the ability to judge the quality by visual examination. Conditions, however, are improving each year and more attention is given to the inspection and testing of materials.

The inspector or engineer responsible for the inspection of materials at destination should examine all shipments of fine and coarse aggregate upon arrival to determine so far as possible from an examination of the top of the car, if the material complies with the general requirements of the specifications relative to uniformity, cleanliness and freedom from foreign or objectionable material. Whereas the inspector at the plant has the opportunity to thoroughly inspect and sample the car as it is being loaded and is thus in a position to judge the quality of the entire shipment, the inspector on the job has much more of a problem in the inspection and sampling of the car prior to unloading.

Providing the quality and grading of the material are satisfactory so far as is possible to determine from a visual examination of the car, the next step is to take samples for field or laboratory tests. When samples are to be taken prior to the unloading of the car, special efforts should be made to secure as nearly representative samples as possible. Samples should be taken at a number of points including the middle and both ends of the car by digging holes at least two or three feet deep and starting at the bottom of each hole, drag the point of the shovel up the side. The samples thus

taken from each hole should be mixed and the composite sample quartered down to the desired size.

While ordinarily samples of each shipment are taken for either field test or laboratory test, it may be that at times the aggregate will be of such a character that the car may and should be rejected outright on the basis of visual examination alone; for example, a car of sand may be excessively dirty or badly contaminated with foreign material. Coarse aggregate for concrete, such as gravel, may be badly coated or contain clay lumps. Crushed aggregate, such as stone or slag, may obviously be of improper grading or may be exceedingly non-uniform, containing perhaps pockets of fine material or dust in the center and excess coarse material at the ends. In cases of doubt the material should be subjected to the field tests on the job or samples sent to the laboratory, but there are many instances in which the quality or grading is obviously so far at variance from the specifications that the inspector may be fully justified in rejecting the material without test.

Methods of Sampling

The methods of sampling are considered separately from the inspection, for the reason that the sampling of materials is required under both material surveys and preliminary surveys as well as under routine inspection, whether at the plant or at destination. It is not considered necessary to go into detail as to just how the samples shall be taken or the quantity of sample required for each class of fine and coarse aggregate, for the reason that the methods of sampling aggregates are covered in one of the standard methods of the Society.[1] This method has been approved as "American Tentative Standard" by the American Standards Association and also with only slight modifications as a "Tenative Standard" of the American Association of State Highway Officials.

It is believed that experience has demonstrated that the methods of sampling prescribed in this standard have proved very satisfactory and practical, and that any engineering organization formulating instructions to inspectors would do well to refer to this standard as the basis for its sampling requirements.

Field Tests

A discussion of methods of inspection would not be complete without reference to some of the more important "field tests" which are now in more or less general use in connection with the inspection of aggregates.

Field tests may be made at the source of supply or at destination. The most important of the tests in the field on fine and coarse aggregate are the following:

1. Screen Tests;
2. Silt Test;
3. Colorimetric Test for Sand; and
4. Weight per Cubic Foot.

Screen Tests:

The field test in most general use is the grading or screen test of the aggregates. In many instances, particularly with crushed rock, the material has been subjected to complete laboratory tests for quality, so that it is only a matter of determining whether the aggregate is of satisfactory grading and uniformity. For this purpose the inspectors are furnished with screens and sieves, and either scales for determining the proportion of the various sizes by weight, or suitable cylinders or containers for volumetric determinations. The grading of an aggregate can be determined in the field practically as accurately as in the laboratory, therefore, except in very extreme cases, it should not be necessary to hold up construction work pending the results of laboratory tests when only the size is in question.

Silt Test:

The percentage of silt or clay in a sample of sand may likewise be determined in the field by a proper washing or elutriation test. The most accurate and satisfactory method is by the weight method, in which the silt is washed out in a specified manner and the loss in weight determined as described in the Society's Standard Method of Decantation Test for Sand and Other Fine Aggregates (D 136—28).[2] This method requires a source of heat for drying out the sample prior to and subsequent to the washing. A more rapid and simpler method sometimes employed as a field test consists in shaking a sample of sand with water, in a glass jar or cylinder, after which it is allowed to stand for a stated length of time and the percentage of clay or silt settling out on top of the sand estimated. The value obtained by this method is usually from two to four times that obtained by the weight method, depending largely upon the time allowed to settle; hence this method is only considered as a guide and may in cases of doubt necessitate a check determination by the laboratory.

[1] Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (D 75—22), 1927 Book of A.S.T.M. Standards, p. 473.

[2] 1928 Supplement to Book of A.S.T.M. Standards, p. 161.

Colorimetric Test:

The colorimetric test for organic impurities in sand is one of the field tests which is now being used quite extensively. The test consists, briefly, in adding a 3 per cent solution of sodium hydroxide to a given volume of sand in a graduated bottle and noting the color of the solution after 24 hours. If the liquid is colorless or has a slight yellow color the sand may be considered satisfactory in so far as organic impurities are concerned. The method is described in the Society's Standard Method of Test for Organic Impurities in Sands for Concrete (C 40—27).[3] The field method is the same as the laboratory method described in the standards, except that a color chart is used for comparison instead of employing colored solutions prescribed for the laboratory method.

Weight Per Cubic Foot:

One of the usual requirements in specifications for certain classes of coarse aggregate such as blast-furnace slag is a weight per cubic foot requirement. On inspections covering this type of aggregate, therefore, it may be required that this determination be made in the field. A determination of the unit weight of other coarse aggregates is also sometimes necessary in connection with weight proportion of aggregates for concrete and also in connection with designed mixes, where proportions are based on compacted weight of aggregates. A description of the method appears in the Society's Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29—27).[4]

[3] 1927 Book of A.S.T.M. Standards, Part II, p. 123.
[4] *Ibid*, p. 120.

Those cited are the more important and generally used field tests in connection with the inspection of aggregates. Other special field tests employed where conditions require include such tests as a determination of the percentage of shale in gravel; the percentage of coke or coal; the percentage of clay lumps; the percentage of soft fragments; and the percentage of thin or elongated pieces. In some cases also where a crushed gravel is specified, it may require a field determination of the percentage of angular pieces in the aggregate.

Summary

It has been estimated, it is believed conservatively, that of the billions of dollars expended in this country annually for construction work, not less than fifty per cent is represented by the cost of materials incorporated in the work. Mineral aggregates play a most important part in this construction program, exceeding, from the standpoint of volume any other class of material used in construction work. Our highways and streets to the extent of over 90 per cent are composed of mineral aggregates. Concrete construction of all kinds will average approximately 85 per cent by volume of mineral aggregates.

It goes without saying that the protection of the enormous investment represented by this construction program makes mandatory the assurance that proper selection of materials be made. This can only be done by adequate inspection and test methods. This paper has attempted to outline an efficient and practical procedure to follow in the inspection of mineral aggregates, both at their source and at destination.

Discussion on Mineral Aggregates[1]

Inspection of Aggregates

MR. M. H. ULMAN.[2]—Mr. Crum discussed tolerances in specifications. This subject needs considerable clarification, for specifications should be so written as to include the tolerances which will be permitted and no variation should be allowed from them. Specifications should be written by one who is thoroughly familiar with the desirable qualifications of materials for the intended use. If variations over and above the specification tolerances are permitted by the consumer it is probable that this will become progressive as additional requests are received from the producing interests when materials fail to comply with the specified requirements.

In the papers presented, no reference was made to the desirability of the producer having his own testing organization, so that he can be assured that all materials shipped comply with the requirements of the particular consumer, and by this method, which I feel is the most desirable, the final control can be exercised by the consumer of the materials as received.

[1] The discussion given above on "Inspection of Aggregates," was taken from the general discussion on Mineral Aggregates included as a part of the Symposium on Mineral Aggregates.
[2] Assistant Engineer of Materials, Pennsylvania State Highway Department, Harrisburg, Pa.

Mr. Rea has discussed a number of factors to be considered in inspection. To these I would add the amount of coatings on fragments of rock and any clay lumps in the shipment. This information together with information on amount of foreign material is of extreme importance when any controversies occur between the producer and consumer as to the materials' compliance with specifications. If condemnation has been made for any of these causes based on visual inspection it is most difficult to satisfy the producer that the correct interpretation has been made.

MR. R. W. CRUM.[3]—I think in most cases it is possible to set the tolerance limits in the specifications, and whenever possible they should be included therein, and not left to the discretion of the engineer or inspector on the work.

MR. A. S. REA.[4]—In regard to the determination of coating on aggregates referred to by Mr. Ulman, I feel personally that this can best be determined in the field by visual examination. We have found that in many cases it cannot be determined satisfactorily on samples sent to the laboratory, and I believe, too, that a quantitative determination in the field may not in every case be conclusive. For example, a very small percentage of adhesive clay may be more objectionable than a much higher percentage of a more granular coating. Our instructions to engineers and inspectors provide that all aggregate for concrete shall be examined for coating on the job.

MR. L. E. WILLIAMS.[5]—With reference to producers having their own plant inspection in order to produce material which will ultimately be acceptable on destination inspection, we have found that seldom will two men take separate samples of a carload of material and get identical results. If the material is anywhere near the limits of the specifications, we have to rest our case on the inspection of the people to whom we are furnishing it. If that inspection is made at the plant, that ends the argument; rejected cars can be taken care of, whereas rejection at destination often involves very considerable loss to the producer both in freight charges and also ultimate disposal of the material. Your own forces might make the most conscientious inspection possible at the plant and yet, with perfectly conscientious work on the part of the purchasers, by a difference in sampling, the car might be rejected.

[3] Director, Highway Research Board, National Research Council, Washington, D. C.
[4] Chief Engineer, Bureau of Tests, Ohio Department of Highways, Columbus, Ohio.
[5] Plant Manager, Roy Sand and Gravel Co., Detroit, Mich.

In our own state we have exceptionally close cooperation, at least so far as the state highway department is concerned. It is practically all plant inspection, and the spirit of those inspectors almost invariably is to assist the producer to get the material on the job that is acceptable; with that cooperation we have comparatively few rejections, providing the producers do what they should do. On the other hand, we have other customers where we have destination inspection on almost identical specifications, and, due to differences in sampling at destination, we often have considerable trouble.

There is one other point that I should like to touch on; it is not strictly a matter of sampling, but it is related to the ultimate use of aggregates. Some few years ago, our company in cooperation with the University of Michigan, had two men, who were post-graduates at the University, carry out investigations of sampling methods with particular reference to how the material carried through to destination. By that I mean taking a series of carloads at the plant, taking samples by several different methods, then following those carloads through to destination, taking samples out of the stock piles where used, out of bins where bins were used, and ultimately taking batch samples at the mixer. Incidentally, we developed a method of taking samples off the loading belt, where a loading belt was used at plant, that we believed was the most representative possible sample of the car in question. At the mixers, in a great many cases, the material was no longer recognizable, due primarily to segregation in handling.

Speaking at least for Michigan producers, we are perfectly willing to furnish materials to the best of our ability under any reasonable specifications—I mean specifications written sufficiently broad to be within the limits of normal plant production. However, we feel that we should not be required to meet exacting specifications when that same material is handled in such a way that, by the time it reaches its destination, due to segregation and methods of handling, one gets one batch which may run outside of the specifications on one side and the next batch may run outside in the other direction. We are not asking for leniency in specifications or in inspection, but in the interest of better concrete and materials being used to the best advantage, we do feel that there are a lot of weak points in the handling of materials between the production plant and destination, that should receive careful attention.

MR. A. T. GOLDBECK[6] (*presented in written form*).—It can be safely said that no other part of the procedure concerned with the purchase of aggregates gives quite so much trouble to both producer and consumer as the question of adequate inspection. Both parties have their own special views on this question and the methods pursued are oftentimes admittedly not the best, but are governed by expediency. The commercial producer would like to feel that when carloads of aggregates leave his plant they are entirely suitable for the work and will not be rejected when they arrive at their destination. Unfortunately, however, with the method of inspection practiced in many of the states, that of inspecting at point of delivery, it too frequently happens that many carloads in a single shipment are rejected for some reason which sometimes is trivial and could readily have been obviated had the matter been thoroughly understood at the producing plant.

In some localities high-class materials are not available and it becomes necessary to use the best materials procurable which are satisfactory, provided they are rigidly controlled. When materials such as these are inspected at the site of the work, they are sometimes rejected and the producer suffers a considerable loss with the result that certain producers have refused to ship material unless plant inspected. At other plants producing unquestionably high-grade material, with methods of production which in every way are first-class, plant inspection becomes a needless expense to the State for it is seldom the case that such material does not comply with specifications.

Too commonly inspectors at the work, instead of following specifications, have their own ideas as to how the materials should be graded and the same plant shipping aggregate to different inspectors in the same state has frequently had to change the gradation merely to suit the individual whims of the different inspectors. Yet all of this aggregate was supposed to comply with the same specification. Such conditions, obviously, should not exist. This is a matter of educating the inspectors by the State.

Too commonly expensive rejections are made on the basis of the most superficial "toe" inspection by inspectors who have no knowledge of production methods and their effect on gradation. Some inspectors feel it their duty to reject a given percentage of shipments to demonstrate their efficiency, completely overlooking the fact that their rejections lead to high costs and that it is really their duty to assist the producer in every possible way so that his material will be accepted. Complete and sympathetic understanding between producer and the inspection force will do much toward the production of better materials, thus speeding up the work and leading to better construction. Good engineering and good inspection demand not that the materials supplied to the work be perfect in every detail irrespective of the cost involved in their production but rather that they be of a quality entirely satisfactory for the work and produced at a reasonable cost.

MR. SHREVE CLARK.[7]—Mr. Goldbeck requests that all the provisions for tolerances be written into the specifications. That would be very good if it were possible, but when we encounter coatings on stone, I know of no way in which that material or its condition or characteristics can be described so that an inspector will be able to accept or reject it on that factor.

On many types of crushed stone varying layers of dust are collected, dependent upon the moisture in the air, whether it is foggy or rainy weather, and the dust conditions about the quarry. This dust may or may not be of such a character as would interfere with its use. In many cases the layer of dust does not interfere with the use of this material as a concrete aggregate. However, in case it is to be used with bituminous material, it is absolutely fatal, and I know of cases where the layer of material on the outside of granite or sandstone is not at all detrimental for use as concrete aggregate, but it will prevent the adhesion of bituminous material.

I have a case in mind of a limestone that had a slight layer of dust on it, or rather you might say slime, because it was a very slight layer indeed, but the material was accepted because it was considered that stone of this character was satisfactory for concrete. It happened to be mixed in a mixer with a cutback asphalt for the purpose of putting it as a surface on a road. It was well coated in the stock pile, but in a day or so

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[7] Senior Assistant Engineer, Virginia Department of Highways, Richmond, Va.

a very heavy rain fell and completely washed the bituminous material off the surface of the pile and the whole thing was a complete loss, all on account of a surface layer of fine material on the stone.

If Mr. Goldbeck will tell us how to write specifications to prevent such a condition, we will be glad to know it, because that holds for dusty layers on the surface of any aggregate.

MR. D. D. MCGUIRE.[8]—I think that we, as an organization, should have respect for inspection, in that we should guard against such clauses in specifications as "clean," "sound," "durable," and "free from." One cannot ask an inspector to adhere to specifications that contain clauses impossible to produce. I think this Society should consider this very carefully in developing specifications.

MR. STANTON WALKER[9] (*by letter*).—Messrs. Crum and Rea have confined their discussions to inspection methods. While this subject is of utmost importance to the producer and consumer of mineral aggregates, it is felt that a thorough analysis of it requires more complete consideration of the principal basis of difficulties and misunderstandings resulting from inspection—the specifications. Inadequate and unscientific specifications probably are responsible for more of the difficulties laid at the door of inspection than any other cause. Another source of misunderstanding is the interpretative clause, not incorporated in the specifications but enforced as a part of them, which is attributable to the inadequacy of the specification.

Inadequate specifications, for the most part, are not due to carelessness or lack of thoroughness on the part of the engineer writing them, but are due to lack of definite information on the effects of the various characteristics of mineral aggregates on the finished product. The familiar and indefinite clause "free from injurious amounts of" is the bone of contention in many instances. Specifications for grading written without sufficient regard to the characteristics of available materials and which cause the producer to work within a narrow range near the limits of the specifications are frequently the cause of the inspector having difficulty in deciding on the suitability of the material.

Many of the difficulties arise, of course, from the causes emphasized by Messrs. Crum and Rea—faulty or unintelligent inspection methods. These, however, can be corrected by education. No one is more anxious than the inspector to have a definite, clear-cut basis for the determination of the suitability of a material.

Examples of misunderstandings and hardships resulting from the several causes mentioned above could be given without end. While a complete discussion of them might leave the erroneous impression that the life of the mineral aggregate producer is almost entirely filled with difficulties with inspectors and specifications, a few examples should be of interest.

Many specifications for grading leave entirely too much to the judgment of the inspector or to supplementary clauses not a part of the specifications. The specifications for grading of gravel of a prominent state highway department requires only that 100 per cent shall be finer than 2¾ in. and that not more than 5 per cent shall be finer than ⅜ in. Except for the phrase "graded uniformly," a literal interpretation of such a specification permits the use of, for example, 2 in. to 2¾ in. material, or ⅜ in. to ½ in. material. Obviously, such a range in sizes is not permitted and personal opinion must enter into the determination of the suitability of the gravel.

Specification limits on soft particles, with the lack of definite information as to how to identify a "borderline" soft particle, are a frequent cause for lack of consistency in accepting or rejecting material by different inspectors.

To cite the examples of unintelligent inspection would require too much space and serve no definite purpose. That difficulty is not fundamental and will be corrected with education and increased knowledge. Greater emphasis on clear-cut, definite, and scientific specifications will make inspection positive and permit the producer to furnish material which will make inspection a matter of routine.

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[9] Director, Engineering and Research Division, National Sand and Gravel Assn., Washington, D. C.

Low Cost Paved Farm-to-Market Roads[1]

By Sam H. Thompson, *President*
American Farm Bureau Federation

IN dealing with any economic problem, it is natural for the individual to think of that problem, first of all, as it affects him as an individual, as it affects his family and his own community. In talking to you this morning about farm-to-market roads as a national economic necessity, I should like, first of all, to think of farm-to-market roads as a necessity in my own state —Illinois. I should even like to think first of roads in my own county—Adams County—as they apply to one of my own farms.

In Adams County, over on the Mississippi River, I have a farm that is not on a year-around road. My farm is not unique. There are many others in that county that do not enjoy roads that can be used the year around. A short time ago the farmers in that community got together with the county and worked out a system for getting a partial secondary road system. This was done by the farmers themselves contributing jointly with the county the funds from which these secondary roads were built. I contributed my share as agreed upon for every acre in this farm of which I spoke. The money was used in building some secondary roads but the nearest road to my farm is one mile away. On an average, three months out of the year that road isn't worth a nickle to me because I cannot reach it from my farm. The intervening mile of mud makes it impossible.

That mile of mud is costing me money. It is not only costing me money but it is costing the merchants of the community, it is costing the railroads, it is affecting in its small measure our entire economic structure.

Let me illustrate. Ten days ago I paid twenty-five cents a ton mile to move sixty ton of limestone six miles from the railroad to this farm. In other words, it cost me $1.50 a ton or $90.00 to move the entire amount. This limestone cost me $2.10 a ton laid down at the railroad.

You men are interested in building roads but I do not feel that I am becoming too technical when I mention the need of limestone in Illinois if we are to maintain the proper condition of our soils. I must confess that with all the information I have as to the added fertility this sixty tons of limestone would give my farm, I had to stop and think twice before I could pay $90.00 hauling charge. Now if we had had a year-around road to our farm, this limestone would have been moved during the winter by the men on the farm in our own trucks when trucks and men were idle. There would have been no particular costs other than the regular overhead of the farm. As it was we were forced to move it hurriedly at a time when the dirt roads were dry and hard.

In that one illustration of something that occurred in my own farming experience within the past two weeks you have a picture which portrays the whole theme of my address. You see the farm contributing directly to the construction of roads and getting in return roads passable only part of the year. You see there the impossibility of the farmer using modern transportation facilities. You see in this experience of mine the added cost of farm necessities and you further see the inducement toward curtailment in our purchasing.

It takes no particular imagination to apply this illustration of the movement of sixty tons of limestone to a farm in Adams County, Illinois, to the hundreds of thousands of other farms, similarly situated, in every state in the Union.

A moment ago I said that if we had had a year-around road to this farm we would have moved the limestone at our leisure and in our own trucks. In this address we are concerned with the subject of roads but in passing I must refer to the motorization of the farm transport. The motorizing of the transport has transformed industry and commerce during the past decade. This motorization at present is denied agriculture. No one can question but that it would aid materially in solving the farm product distribution problem. If American agriculture is to maintain its part in national progress, if it is to maintain its share in providing the American standard of living farmers must be allowed to utilize modern machinery, equipment and tools, both in the way of production and distribution. Without motorized transportation, agriculture cannot make its proper contribution to the economic progress of the nation.

But to return to the subject—farm-to-market-roads —and to consider these roads from their national standpoint, let us for the moment consider total figures.

[1] Presented before the Eighth Annual Asphalt Paving Conference, October 29, 1929, West Baden, Indiana.

We are told that there are 2,484,822 miles of unimproved dirt roads in the United States. Add to this mileage the thousands of miles of dirt roads that have some grading and drainage and the total figures come nearer three million. It is evident that there are approximately two and one-half million miles of road that cannot be used during part of the year and at all times these dirt roads constitute an added tax on men and equipment.

Of the 6,250,000 farms in the United States, nearly five million are located on dirt roads. There are 1,998,704 farms on dirt roads that boast some grading and some drainage but there are 2,747,732 farms located on absolutely unimproved dirt roads. That makes a grand total of 4,746,436 farms out of 6,250,000. Of the balance, we find less than a million on gravel, and less than half a million on year-around surfaced roads.

And yet in spite of these startling figures illustrating so clearly that our American road building program has so signally failed to serve American agriculture, it is significant to note that in the first session of the 70th Congress the report of the Committee on Roads of the House of Representatives contains very little testimony or interest in the subject of farm service roads. There are 652 closely printed pages of that report. The report gives the testimony of 72 different witnesses and of the 72, only four spoke at any length or with any particular emphasis on the subject of secondary roads. These four were Congressman B. Carroll Reece of Tennessee, Congressman Malcolm C. Tarver of Georgia, Carl Howard, president of the National Rural Letter Carriers Association and Ned H. Goodell, vice-president of the National Rural Letter Carriers Association.

The Federal Aid Road Act of 1916 was the first statute applying the federal aid principle to road improvement. This act provided 75 million dollars a year for the fiscal years 1917 to 1921 and laid down the principles on which federal aid has, with slight modification, been administered.

In November of 1921, a Federal Highway Act, the Phipps-Dowell bill, was approved which established the general federal aid highway plan designed to provide roads serving every city of 5,000 population or greater and further designed to penetrate within ten miles of the homes of all the people in the country. This 1921 act was a vast improvement over the first plan suggested in that year, for earlier a bill known as the Townsend act had been proposed. This Townsend bill provided that all federal monies should be spent in the construction of a great system of transcontinental scenic and military roads.

Back in 1921 the American Farm Bureau Federation was the first farm organization to definitely oppose this Townsend bill and to take the first step to secure roads of some service to agriculture. The result was the adoption of the Phipps-Dowell bill outlining the policy which I have already stated. This policy adopted in 1921 was an improvement but it has not been sufficient. In the past eight years, vast sums of money have been spent by the federal government, federal appropriations have been matched by state appropriations and the final result is that only five per cent of the farms in the United States are served by year-around roads. We still have a long way to go.

Often when we have discussed the lack of farm-to-market roads, it has been assumed that the figures we quoted, the illustrations we used, were drawn from the backward states—those states that have shown little or no progress in many different ways. Or it has been assumed that we have drawn our figures and illustrations from the western states with their vast distances. This is not so.

For example, turn again to my own state—Illinois—a great midwestern agricultural state, a state that has expended many millions of dollars on roads. We find in that state, under the state road system assisted by federal aid, a total mileage of 9,889 miles. This was at the close of the year 1928. Of these 9,889 miles we find that 3,637 are still dirt—roads impassable certain months in the year and mind you, I am speaking only of the state highway system. If we turn to the rural roads, those under county and township control, what do we find? According to the latest figures available, those at the close of 1927, there were in Illinois 87,730 miles of these rural roads and of this mileage, 74,681 were non-surfaced dirt roads.

In talking of farms and farm conditions, we always think of Iowa as this is one of the greatest farm states in the Union. Examining the same figures in Iowa that I have used in illustrating in Illinois, we find this to be the case; 7,184 miles in the state highway system and at the end of 1928, of the 7,184 miles, 2,013 miles were non-surfaced dirt roads. In the rural local roads, we find that Iowa boasted a total of 96,558 miles and of this total, 89,187 miles were non-surfaced dirt roads.

But the Midwest alone is not the only portion of the country in which there are farmers. New York state, while it boasts the largest city in the United States and the second largest in the world, also boasts a great agricultural development. In New York state

we find the state highway system a total of 13,917 miles and of this mileage 3,356 miles were still unsurfaced dirt roads. In the local rural roads we find in New York a total of 85,560 miles with more than half —to be exact—46,283 miles still unsurfaced dirt.

Pennsylvania has in its state highway system 13,330 miles and of this 4,164 are still unsurfaced dirt. In its local system, Pennsylvania has 79,074 miles. Of this 63,678 miles are unsurfaced dirt.

Jumping clear to the West Coast, California has 6,572 miles in its state highway system. Of this, 2,645 miles are still unsurfaced dirt. California has a total of 78,583 miles in its local road system and of this, 58,607 miles are yet unsurfaced dirt.

In the Southwest, Texas has in the state highway system 18,728 miles of which 7,979 are non-surfaced dirt roads. In its local system, Texas has 169,836 miles of which 155,990 are unsurfaced dirt.

Those are some figures selected at random to illustrate conditions existing in various parts of the United States. The total amount of unsurfaced dirt roads in relation to the rural local roads is appalling but this condition is truly not as startling as to see the large proportion of the state highway systems yet unsurfaced. When we think of the millions upon millions of dollars that have been spent, it seems impossible to think of how comparatively few miles have been put in permanent condition.

On August 31 of this year, reports indicated that the total mileage of permanent roads in both Federal and State highway systems was 78,797.6 miles. At that time there were 10,321.7 miles under construction. These ten thousand miles were to cost $259,691,965.90 of which $104,613,910.33 was to be federal money.

The Panama Canal cost in the neighborhood of 370 million dollars. We have been spending on roads every two years the price of the Panama Canal and yet only five per cent of the farms in the United States are served by year-around roads.

Based on my own experience as road commissioner in Adams County, Illinois for nine years, I feel safe in saying that people receive less benefit from road money than any other money put in taxation, due to the fact that so much of the road improvement is not permanent. Money spent on impermanent road improvement is in a large measure money wasted. I regret that I have to acknowledge that so much of the road improvement in Adams County during the time I was road commissioner was of impermanent character.

During this discussion we are trying to decide whether or not the low cost paved farm-to-market roads are a national economic necessity. So far we have considered the situation as it exists today. We have come to a realization that only five per cent of the 6,250,000 farms in the United States are served by year-around roads. We have touched briefly on one or two of the effects. Now, for the moment, let us consider some of the major results of our lack of farm-to-market roads.

For the past ten years, newspapers and magazines have discussed fully the economic plight of agriculture. During the last great national political campaign, all of us heard dozens of speeches dealing with the farmer's plight. In every case the major thing discussed was the marketing of farm products. Agriculture has kept pace with industry in improving its production practices. But there has been apparently something radically wrong with the machinery used in the distribution of these products, something wrong between the time the product left the farm and when it reached the ultimate consumer.

Through seven years, Congress carefully considered this problem. This year we have seen a special session of Congress called with the express purpose of dealing with the agricultural problem. Out of this special session has come legislation which has resulted in the setting up of a Federal Farm Board. This Federal Farm Board is charged with the duty of affecting improvements in the marketing of farm produce.

It does not take any great study of the agricultural situation to see that the difficulties in the distribution of farm produce starts right at the farmer's gate. The economic life of the United States is geared to rapid transportation. The airplane, the bus, the truck, the automobile, the electric line and fast freights move the commerce of the nation, but the produce of the farm moves from the farm to the next transportation system on the same sort of road that existed a hundred years ago and either by the same general device used a hundred years ago or if by modern motorized equipment, with the burden of a terrific equipment wear and tear tax.

One of the problems of the marketing of farm produce is occasioned by the market glut following the harvest of particular crops. One reason for that glut is the fact that the farmer must move his produce to market during the period of a few weeks when his dirt road is dry and hard. Year-around roads would en-

able him to spread this period over a number of months and that would prevent this seasonal glut that penalizes American agriculture millions of dollars each year.

A natural sequence to the effect of a dirt road on agricultural use of motor transportation is its effect on the motor industy. I believe you have another talk on this program this morning having to do with the effect of farm-to-market roads on the automobile industry. I was struck with figures recently presented showing that at the end of 1927 there were only 44 yards of permanent highway for every motor vehicle registered. And someone has recently stated that if the new cars manufactured each year were placed end to end they would just about stretch the length of the permanent roads put in during the year. In March of this year, in the Atlantic Monthly, a writer—Ernest Elmo Calkins—had this to say:

"Before the buyer of motor cars realizes that there is no place to drive and stops buying, the movement should be under way to multiply the available road area five-fold by surfacing all existing roads and the motor industry, four million strong, is the unit to undertake it. It has the vested interest in good roads, and is in itself a large enough body to influence the public."

I note statistics for the last several months show a steady decline in the number of motor cars manufactured.

The effect of the lack of an adequate secondary road system does not end with the consideration of marketing of farm products nor its relationship to the automobile industry. There are many other matters of grave importance. Let me refer to the annual farm fire loss. Each year in rural fires 3500 people are burned to death. Each year farm fires destroy $150,000,000 worth of farm buildings, equipment, stored crops and stock.

A little while ago Major General George O. Squier, U. S. A. retired, developed a plan advocating motorized fire fighting apparatus with a rural fire fighting company in each township, equipped with chemical truck with a driver that could be rushed to the aid of any farmer whose house, barn or haystack happened to catch fire. The need of such a fire protection system for American agriculture is apparent from the figures I have just quoted. I believe that such a plan is totally impossible today with only five per cent of our farms being served by year-around roads. Under present conditions during the months when fires are most frequent, such fire fighting equipment could not get within a mile of five million of the farm homes in the United States.

While this inability to develop adequate fire protection to rural America is responsible for a tremendous economic loss, I think it is greatly overshadowed by the effect of the mud barrier on rural education. The little one-room schoolhouse with its meager equipment and poorly paid teacher is rapidly giving way to the consolidated or centralized, well-equipped, sufficiently-manned public school. This is essential if the farm youth of America is to be fitted for modern life.

But the consolidated or centralized school presents a problem. It lengthens the distance from the farm home to the school house. It makes necessary bus or truck transportation for the children. Such transportation cannot be economically available for farm children located off the permanent surfaced highways. A five-year survey by the Bureau of Public Roads indicates emphatically the effect of bad roads on school attendance in a striking way.

Comparable to the restriction on the educational development of rural America is the increased cost of sickness due to unsurfaced dirt roads. In the current issue of Bureau Farmer, official publication of the American Farm Bureau, appears an editorial setting forth some startling figures regarding the cost of medical care for the average farm family. In this editorial it is shown that a recent survey gives the average cost per family for medical-dental-hospital care at $104.94 a year. It is shown that the average farm family pays $7.63 to a doctor to make one home call and 13 per cent pay more than $15.00. It is pointed out that the road condition is the main factor in this high cost of medical attention. The fact that the automobile has become the chief method of travel is an actual hindrance to farmers who can be reached only through unimproved dirt roads.

The facts of this survey of medical cost show that in one state like Iowa, the farm people spend around 21 million dollars a year for medical attention and that a large proportion of this cost is chargeable directly to high cost transportation due to unimproved dirt roads.

A while ago I spoke of the effect of this road situation on the automobile industry. This effect is just as noticeable in the business of the merchants and tradesmen who serve the farmers of the country. With more than two-thirds of the farmers barred from the market-place from two to six months a year by bad roads, it is very reasonable to assume that farm people do not purchase the amount of merchandise they would

if they could reach the market every day. This directly affects the groceryman, the motion picture industry, the clothing store and all other lines of commerce and business.

Closely related to this thought is the possibility of the small town business man broadening his market through an adequate rural delivery system. A well developed system of local roads would enable such a development to take place. It is much more economical for one merchant to deliver merchandise to 50 farmers than for the 50 farmers to take so much of their time individually to go into town to the store to get their merchandise. A secondary road system that would permit a proper delivery system would provide a real economy in national distribution. It would enlarge markets and increase consumption of manufactured products.

In considering the necessity for an adequate secondary road system, pleasure must not be overlooked. A secondary road system would offer a far superior and far more appealing pleasure road than main trunk highways with their heavy bus and truck traffic. It would offer a new incentive for motor excursions for town and city people. It would effectively break down the barrier between the real rural America and the metropolitan areas. It would provide an absolutely new appeal to the city motorist seeking pleasure.

In leaving a discussion of some of the main factors indicating the economic necessity of the development of farm service roads, one must mention briefly the appalling loss of life and destruction of property in auto accidents due in a large measure to congestion on trunk lines. The development of an adequate secondary road system would relieve this congestion and is important from a safety standpoint.

Those are some of the important factors that the American farmer considers in his contemplation of the present road problem. The Farm Bureau organization, consisting as it does of 15,000 community units, 1837 organized counties, of 45 state federations, has been tackling various phases of this problem in a small way during the past ten years. We now propose to go forth in an energetic national campaign, national in the sense that it will be stimulated, supported and sponsored by the National Farm Bureau but local in the sense that it will be handled directly in 1837 counties, to bring about a proper understanding of this road situation and to secure the adoption of a road building plan that will take care of the farmer's road needs.

For every mile of trunk line built we shall insist that there be so many miles of secondary or farm-to-market roads. We believe it is false economy to build trunk lines without secondary feeder lines to give the main lines their full value.

We do not feel that our efforts to secure adequate secondary road systems will necessarily increase taxation. The amount of money now going into roads may be sufficient. We shall seek a more equitable proportion of that money. We shall seek federal aid for secondary roads. We feel justified in asking that a portion of the federal money be diverted to secondary roads because of the general increase in prosperity that would follow such a development. Such a development also would add to the value of already established trunk lines.

We feel that we are justified in seeking federal aid for secondary roads because of the use made of these roads by the government for the Post Office Department. There are in the United States 45,000 rural mail carriers using 1,270,746 miles of rural road. Congressman Reece of Tennessee estimates that if the roads used by these rural mail carriers were year-around roads, the consolidation of routes and other similar economies would make a saving of at least 25 million dollars annually to the Post Office Department.

In testimony that has been submitted to Congressional committees, representatives of state associations of rural letter carriers have pointed out the terrific toll placed on equipment and men through bad roads that must be used by rural mail carriers.

In all states we shall continue our fight to see that an adequate proportion of the funds for road building purposes are directed to the development of secondary roads. An example of what can be done by our state organizations is the outstanding piece of work done by our New York state federation. Through the effort of the federation was secured a reapportionment of road funds which made available 11 million dollars a year for secondary highways in New York. Twenty per cent of the gas tax goes back to the counties for lateral roads. The state assumes full maintenance costs and the like.

Commenting on the result of this campaign, the New York edition of the Bureau Farmer in May of this year said:

"The importance of this particular measure to rural people cannot be overestimated. Less than one-third of the farms in this state are now located on improved roads. With the money made available by this new law, the other two-thirds of the farm population will be brought nearer to their markets, making it possible to step up their whole farm operation."

It is our purpose to bring about a similar result in all our great agricultural states.

Retread Construction in Indiana[1]

By A. H. Hinkle,
Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis, Indiana.

THE program today is devoted to the consideration of "Low Cost Roads." Your Program Committee is to be commended for giving this subject the time and attention it deserves. The study and discussion of "Low Cost Roads" is quite appropriate.

We, who are in the business of road maintenance and construction, sometimes become lost. We allow the turmoil and clamor to cloud the real objectives for which we are striving. We lose the true perspective of the situation and wander in the wilderness just following the crowd.

Even to one standing on the "side lines" it should be evident that many types of road surfaces must enter into an economically developed highway system in order that "misfits" may not occur somewhere along the line between the lightest traveled local roads and heaviest traveled trunk highways.

There is no more logic in arguing that we must always build the same kind of a road than to say we must always build the same kind of house or wear the same priced suit. If we always tried to enforce upon society the same kind of a house or the same kind of a suit there would be a rebellion.

The average citizen is not well versed in road building. He does not understand or realize the wear and tear of traffic on the surface of a road. The length of time required to observe the merits of many road surfaces in order to learn of their relative economic value denies him the full perspective so necessary in making a study of the merits of each road surface. The study is complicated and tedious and is left to others to work out. Furthermore, the pocket book is generally tapped in a more indirect way when building and maintaining highways than where one buys a suit or builds a house for himself and for this reason the average citizen frequently gives little concern to this subject.

The greater speed of vehicles, together with the increased use of balloon tires, has made the dusty type of road surface objectionable, and out of place wherever the traffic is more than a few hundred vehicles per day or where the roadside is occupied by homes. Relief from the dust may be accomplished by the use of calcium chloride, oil, one of the types of cheaper bituminous tops or one of the higher priced pavements.

During the past year our State Highway Commission faced about 90 miles of old roads with Bituminous Retread top.

I know of no road surface that fits in the gap between the traffic bound surface and the higher priced pavement any better than the surface we term "Bituminous Retread Top." This surface can be constructed very smoothly. It is dustless and easily maintained and maintenance costs are not high when the old road to be reclaimed has sufficient width and strength.

The Bituminous Retread Top, with which this paper is primarily concerned, as we have been building it, consists of a mixture of bituminous material and crushed stone, slag or gravel, made by several applications of the bituminous material to a layer of the aggregate spread on the old road. The mixture is kept smooth and uniform by the use of a grader or planer, until the bituminous material hardens sufficiently to cause the aggregate to compact under a roller. The aggregate is rolled after the applications when the bituminous material is in the proper stage of curing. The surface voids that can not be closed by rolling are filled with covering material (¾" aggregate), *just preceding the third application of bituminous material.*

I shall comment on some of the salient features of this type of surface, leaving the specifications to be consulted for full details of the construction.

Preparing the Old Road As a Base

This Bituminous Retread Top has been built on old brick and other types of pavements that have become objectionable because of roughness and disintegration. The holes and depressions in the old pavement were first properly patched. Generally it has been built on an old gravel or stone road. It may be placed on any kind of an old road that is sufficiently strong to carry the load that is to go over it. It may be necessary to level and strengthen the old gravel or stone road. This may be done very economically by adding a lib-

[1] Paper presented at the Eighth Annual Paving Conference, West Baden Springs, Indiana, October 28 to November 1, 1929.

eral application of metal the preceding fall, winter, or early spring, which is compacted by traffic and "drag maintenance;" or by the use of a roller and stone screenings added to coarse aggregate as in waterbound macadam work.

Use of Road Oil to Solidify Loose Material and "Level Up" Old Road Surface

Our experience indicates that the cheapest building up as well as leveling of the base, can be affected by treating the old road surface coated with 1" to 3" of loose aggregate (sized for ordinary drag maintenance) with ½ to ¾ gallons per square yard of 40 to 70 viscosity Road Oil. The loose aggregate treated with the oil is spread and leveled over the surface with graders, planers and long base drags so as to make a perfectly smooth base on which to place the aggregate for the Retread Top. Superelevations and depressions in the old surface can be built up by successive applications of loose gravel or stone and the oil. The oil is of a sufficiently heavy grade to cement the loose aggregate and hold it in place after a few days drying. Traffic may be permitted to use the road during this operation.

The use of Road Oil to solidify a layer of loose material on the old road is the most valuable feature put into practice in recent years in developing a low cost road that is better than a dragged type of surface. The oil gravel mixture not only adds strength to the base but it also forms a more or less impervious layer which sheds surface water and also breaks up the capillary attraction from the road base into the top course. It also greatly facilitates leveling the base and thus helps to obtain a smooth riding finished surface.

Aggregate and Spreading of Same

Aggregate consisting of No. 2 (1½" to 2½") or No. 3 (¾" to 1½") size (the coarser size is preferable) is spread upon the base prepared as described above. The leveling of the aggregate is done by graders, drags, maintainers and harrows. The harrowing is necessary if the aggregate contains much fine material, as the harrowing operation will drop the fine material to the bottom and bring a more uniformly coarse aggregate to the surface, where it is most desirable in producing a uniform surface condition. It is always necessary to do a certain amount of hand finishing in trimming the edges and "spotting up" the low places, that is, filling depressions with uncoated aggregate before the application of the bituminous material, or with the bituminous coated aggregate after the application and when the rolling is in process. *However, the cheapness of this type of surface is due largely to the mixing, spreading and leveling operations being done mechanically, which reduces the hand labor, and hence the cost, to a minimum.*

If the coarse aggregate is a very hard stone it may be rolled one or more times before the first application of bituminous material. If a comparatively soft aggregate is used, *no rolling should be done* before the first application. There is little to be gained in rolling gravel before the first application.

The aggregate used for covering material should consist of a hard material of about No. 4 (¾") size and is applied to the surface and swept into the voids *just preceding the third application of the bituminous material.*

Bituminous Material, Its Application and Rolling

Amount of Bituminous Material

The Bituminous Material is applied to the aggregate in at least three applications. More may be used. The total amount of bituminous material required as well as the amounts used in the different applications will vary with the depth of aggregate and hardness of the stone. As an example on our average limestone, the different applications of bitumen on 3½" of loose aggregate may be 0.4 gallon on the first, 0.3 gallon on the second, and 0.3 gallon the third coat, with perhaps a 0.2 gallon surface treatment applied before the following winter.

Grades of Bituminous Material

Various grades of bituminous materials have been used in this class of work with very satisfactory results. The most common material we have used is material meeting our specifications for Liquid Asphalt CB (cut back Asphalt with Specific Viscosity 150 to 200 at 122°F) and Tar TM (Specific Viscosity 30 to 60 at 40°C). If the work is done in cool weather it is more desirable to use the more Liquid Asphalt AC (vis. 50 to 100) which differs from CB only in the greater amount of distillate it contains. The lighter bitumen makes the aggregate more susceptible to mixing and leveling with the grader or planer. However, in warm weather the heavier grade of asphalt will give quicker results at slightly less cost.

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Asphalt OH-2 has frequently been substituted for the liquid asphalt in the 2nd application in order to reduce the cost. The OH-2 usually costs about two cents per gallon less than the liquid asphalts. Its use also permits the rolling about one day earlier. Since it is desirable to drag the covering material, it is necessary to again use the liquid asphalts for the third application.

Applying the Covering Material

The covering is applied just preceding the third application of the bituminous material. It may be applied direct from a truck and swept over the surface by hand. The brushing of the covering into the voids may be done with a brush attached to a Ford car or light truck. An old carpet or tarpaulin dragged behind the truck will aid in properly placing the covering. The purpose of the sweeping is to roll the covering stone around over the surface until it drops into the voids of the coarser aggregate and fills all depressions thus producing as near a level surface as possible. After the third coat of bituminous material is applied, the surface is dragged with a light drag or maintainer, thus materially aiding in leveling the finished road. The size of covering stone may vary somewhat with the size of coarse aggregate, using a coarser material where the coarse aggregate leaves larger voids in the surface.

Rolling

After each application of bituminous material the surface is rolled with a 10 ton 3 wheel roller. *In no case is covering material applied before the rolling.* By this means a more uniform and smoother riding surface is produced than if covering material is applied between the application of bitumen and rolling. Water is applied to the roller wheels to prevent the bitumen from sticking to them. This rolling should be *spread out over a number of days while the bitumen is hardening.* The important time to secure the best results from the rolling is when the bitumen is sufficiently stiff and "tacky" as to prevent the stone from being "mushed" out of shape by the roller wheels and at the same time not so hard as to be dry and brittle. As the bitumen stiffens and hardens, the rolling should be speeded up. Too much rolling can hardly be done at the proper stage of curing. One rolling when the bitumen is in the proper stage of curing is worth several rollings when the bitumen is too soft or too hard. *All* bituminous mixtures respond most readily to the rolling operation when the bitumen is in the proper stage of curing. The best results are frequently not secured in this class of work because the rolling is not performed at this most desirable time. The proper time to do the major portion of the rolling is governed by the air temperature, sunshine and the grade of bitumen used, as these three factors will control the rate of hardening of the bituminous material.

Alternate Method of Mixing Bituminous Material and Coarse Aggregate After the First Application

Two distinct methods of manipulation have been followed after the first application of bituminous material. The first method consists in harrowing and blading the coarse aggregate after the first application of bituminous material, so as to thoroughly coat all the stone before rolling. In the second method, the harrowing and blading after the first application of bituminous material is omitted.

Condition of Aggregate

It is extremely desirable that the aggregate be thoroughly dry when the bituminous material is applied. The principal difference between many of the plant mixes and a mix made on the road as described above, is that in the plant mix the aggregate is heated until dry. If the aggregate is thoroughly dry from the warm sunshiny days of summer, the mix made on the road need differ little from the plant mix insofar as the adhesion of the asphalt to the aggregate is concerned. The use of the cut back asphalt also aids in the field mix duplicating the plant mix.

There are many pitfalls which one may encounter in doing this class of work. As with all bituminous mixtures, it is almost imperative that one practice or experiment in doing this work to some extent, or that he have the advice of a person who has had this experience, if he is to be assured of success. We have had foremen who did an excellent job the first time under the advice of a proper instructor, but upon the second attempt he proved a complete failure because of his limited experience and the lack of guidance of a sufficiently experienced man. Outside of the proper leveling of the surface, perhaps the greatest precaution that should be taken is to avoid using too much bituminous material and to use the right amount and grade of covering stone in the finishing process. One should bear in mind that it is always possible to add another coat of bitumen if insufficient has been applied whereupon if at any time too much is applied, it is impossible to remove the excess. The building on the surface of a thick mat of fine aggregate, rich in bitumen should be avoided as this is liable to result in the "waving and rolling" of the surface in later years which is so characteristic in many bituminous surfaces.

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Iowa to Build Roads at $33,000,000 Cost

THE Iowa highway commission has decided upon a construction program for 1930 involving an expenditure of $33,000,000, Fred R. White, chief engineer announced orally January 7.

One thousand miles of primary road will be paved, 200 miles will be graveled and 400 miles will be graded, Mr. White said.

The commission tentatively accepted the 1,000-mile paving program when President Hoover recently called upon States to push their public works programs during 1930. Final decision was reserved until a financing program could be carefully drafted.

Increased receipts from motor vehicle taxes and fees, together with funds available from county road bond issues assures the State of about $45,500,000 for road purposes this year, Mr. White stated. A possible increase of more than $1,000,000 in Federal aid is not included in this calculation.

Fixed charges of the highway commission amount to about $9,000,000 a year, so that the $33,000,000 construction program would leave a primary road fund balance of approximately $3,000,000.

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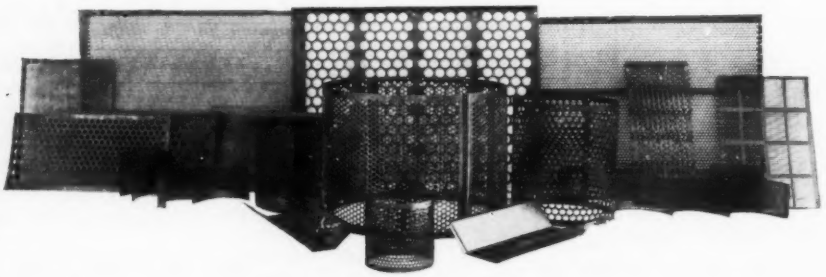

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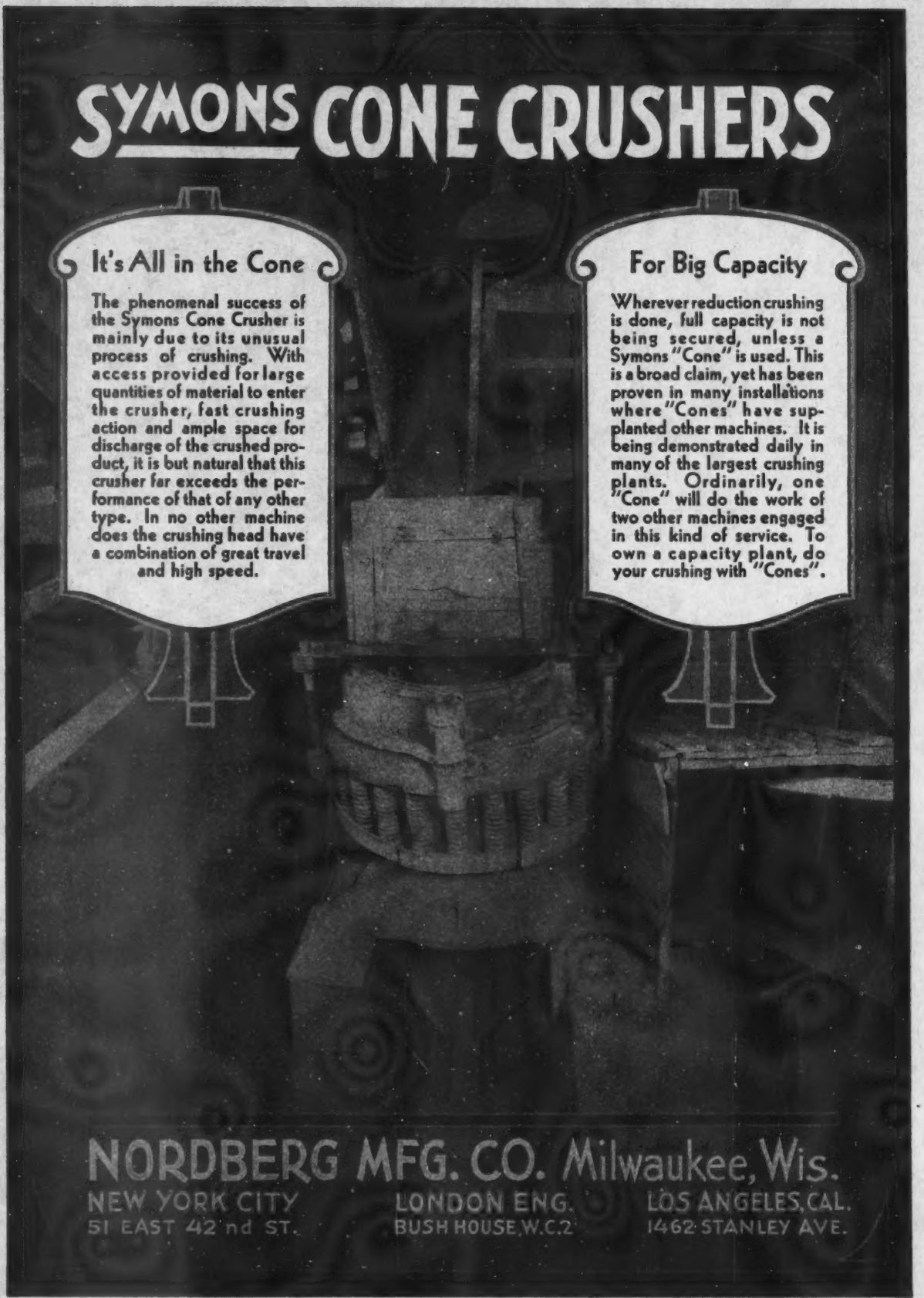

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